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Ileal amino acid digestibility in micronized full fat soybean meal and textured soy flour fed to piglets with or without multicarbohydrase and phytase supplementation

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ABSTRACT

Most amino acid (AA) digestibility values for feed ingredients are obtained using ileal-cannulated pigs. The ileal-cannulated pig model is not used with pigs younger than six weeks of age due to difficulties related to T-cannula implantation in the distal ileum and potential problems related to post-surgical recovery. Thus, the present experiment aimed to determine the digestibility of two ingredients in young pigs using the slaughter method. Fifty 23-d-old weaned pigs were divided into two experiments to evaluate the apparent total tract digestibility (ATTD) and apparent (AID) and standardized (SID) ileal amino acid digestibility in micronized full fat soybean meal (MFFS) and textured soy flour (TS) with or without phytase (Phy) and multi-carbohydrase (MC) supplementation. Each piglet was individually housed in a metabolic cage in a completely randomized experimental design with a 2 × 2 factorial arrangement of treatments to determine the effects of MC (0 and 0.2%) and Phy (0 and 0.05%). During the first 8 d, a diet was formulated to meet or exceed nutrient specifications for piglets. Subsequently, the animals were introduced to experimental diets for 10 d (a 6-d adaptation period followed by a 4-d faeces and urine total collection). A corn/dry-whey/milk-powder diet was used as a reference diet (RD). Ileal digesta was collected at slaughter (45 d of age) after a 4-d adaptation period with a low protein diet (5% casein). There was no effect of MC or Phy supplementation on nutrient and energy digestibility in MFFS. The SID of AA in MFFS without enzymes was on average 6% lower than in published data in the literature (NRC, 2012). Similarly, in TS, no interactions ($P > 0.05$) between enzymes were observed on AID or SID of essential AA. However, Phy supplementation improved the ATTD of crude protein (CP) and the SID of Arg, His, Glu and Pro ($P < 0.05$), while MC improved the SID ($P < 0.01$) of His, Cys, Glu, and Gly. It was difficult to compare these results with values from literature due to a lack of information regarding TS. As hypothesized, the results of experiments reported here suggest that the digestibility of nutrients and energy in MFFS is lower compared with literature values. However, since digestibility of raw materials differs from batch to batch and from experiment to experiment, more researches should be conducted to compare the digestibility of ingredients for piglets in different ages.

Abbreviations: AA, amino acid; ATTD, apparent total tract digestibility; AID, apparent ileal digestibility; SID, standardized ileal digestibility; BW, body weight; MC, multi-carbohydrase enzyme; Phy, phytase; MFFS, micronized full fat soybean meal; TS, textured soy flour; DM, dry matter; GE, gross energy; CF, crude fibre; CP, crude protein; ADF, acid detergent fibre; NDF, neutral detergent fibre; ME, metabolizable energy; RD, reference diet

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1. Introduction

Most AA digestibility values for feed ingredients are measured with pigs fitted with a T-cannula at the distal ileum. The pigs used in this type of study are usually not younger than six weeks to avoid potential age-related T-cannula implantation difficulties and post-surgical recovery. A detailed description of cannula preparation and pre- and post-operative care was previously given by Li et al. (1993). However, nutrient digestibility for weaned pigs might be overestimated because the feed formulation for weaned pigs is still based on digestibility data obtained from older animals with a more advanced physiological stage of gastrointestinal tract development. Age- and body weight-related differences in feed utilization and nutrient digestibility were reported previously (Trindade Neto et al., 2010). According to Marion et al. (2003), an acute phase of decreased digestive enzyme secretion occurs after weaning. When pigs are fed a solid diet, the physiological functions of the small intestine increase gradually (Marion et al., 2003; Boudry et al., 2004). The collection of samples in the distal ileum using the slaughter method could be an alternative to the T-cannula technique (Donkoh et al., 1994).

Soybean products are the primary protein source used to meet the AA requirements of pigs during different growing phases (Lawrence et al., 2003). However, consumption of soybean by nonruminant species can be limited by the presence of antinutritional factors, which can cause flatulency, diarrhoea, and reduced nutrient digestibility (Clarke and Wiseman, 2000). Heat processing procedures such as micronization have been reported to disrupt cell wall components and increase dry matter and nutrient digestibility in pigs (Lawrence, 1973) and poultry (Igbasan and Guenter, 1997). However, the use of micronized feedstuffs to reduce nutrient excretion and swine manure output has not been examined extensively and requires further evaluation (Zhang et al., 2003; Nyachoti et al., 2006). In textured soy flour, the moist extrusion used in the process may reduce the trypsin inhibitor concentration and antigenic properties of soybean, thereby increasing the nutrient availability in the lumen (Friesen et al., 1993). According to Rojas et al. (2016), the energy utilization may be improved by pelleting or extrusion processes, but the response seems to be greater for extrusion in diets that are relatively high in fibre. The cereal source and extrusion affect nutrient digestibility in pigs, and the effects of extrusion depend on the nature of the cereal (Rodrigues et al., 2016). According to Woyengo et al. (2016), the nutritive value of soybean in swine diets could be increased by the extrusion process.

The use of exogenous enzymes may reduce the adverse effects of antinutritional factors as demonstrated by an increase of nutrient use in poultry and swine diets (Kim et al., 2006; Li et al., 2010). Phytase increases the availability of P, which is the third most costly nutrient in pig diets (Woyengo et al., 2014). According to Woyengo and Nyachoti (2013), phytate reduces utilization of other dietary nutrients by binding to them or to digestive enzymes. However, there are conflicting and inconsistent results in the literature regarding the improvement of nutrient utilization from phytase supplementation in pig and poultry diets (Traylor et al., 2001; Adeola and Sands, 2003; Radcliffe et al., 2006; Centeno et al., 2007; Sands et al., 2009; Cowieson and Bedford, 2009; Kong and Adeola, 2011). Plant-based alternative feedstuffs also contain fibre, which limits nutrient use in pigs (Woyengo and Nyachoti, 2011). Therefore, adding supplemental carbohydrases to diets can increase the nutritive value of alternative feedstuffs (Zijlstra et al., 2010). According to Woyengo et al. (2014), carbohydrase supplementation may increase energy digestibility and AA availability. The objective of the current study was to determine the apparent total tract digestibility (ATTD) of nutrients and energy and the apparent (AID) and standardized (SID) ileal digestibility of AA in MFFS and TS with or without multicarbohydrase (MC) and phytase (Phy) supplementation in weaned pigs using the slaughter technique.

2. Material and methods

All research methods and procedures were approved by the ethics and animal experimentation committee at the University of Sao Paulo (project 2843/2012) and followed all the requirements in relation to animal welfare.

2.1. Ingredients and enzymes

The MFFS and TS samples used for the current study were obtained from Nutrialy and The Solae Company, respectively, both of which from Sao Paulo, Sao Paulo, Brazil. According to technical information from the companies, the MFFS was ultra-fine milled and heat treated with infrared radiation. Briefly, the infrared rays (λ from 1.8 to 3.4 μm) penetrate the grain, moving molecules that vibrate 60–150 thousand megacycles per second, heating the grain and vaporizing the water. The urease activity value of the MFFS, determined according to The American Oil Chemists' Society (AOCS, 1980), was 0.09 Δ pH. The range considered optimal for heat-treated soybeans is < 0.20 Δ pH (Butolo, 2002). The TS sample was obtained from soybeans milled to fine powder form and extruded at high temperature and moisture. The urease activity value of the TS was 0.06 Δ pH.

The enzymes were a MC blend of α-galactosidase, galactomannanase, β-xylanase and β-glucanase activities (ENDOPOWER BETA, Uniquimica, Sao Paulo, Brazil) and Phy (GENOPHOS, Uniquimica, Sao Paulo, Brazil). The MC consisted of 40% dehydrated fermentation product from *Aspergillus niger* (PRL 2351) and *Aspergillus oryzae* (ATCC66222) by weight and 60% dehydrated malted barley that provided per kg diet 700; 2200; 30,000 and 22,000 units of α-galactosidase, galactomannanase, xylanase and β-glucanase, respectively. The Phy was a *Saccharomyces cerevisiae*-derived (KCCM 80051), that contained genes of *Escherichia coli* and *Citrobacter braakii* and provided 500 FTU/kg diet. One unit of α-galactosidase was defined as the quantity of the enzyme that liberates 1 μmol *p*-nitrophenol per min. One unit of galactomannanase was defined as the quantity of the enzyme that decreases to half the initial viscosity of galactomannan per min. One unit of xylanase was defined as the amount of the enzyme that generated 1 μmol of the xylose from xylan per minute at pH 5.5 and 50 °C and one β-glucanase unit was defined as the amount of the enzyme that generated 1 μmol of the reducing sugar glucose from β-glucan per minute at pH 4.8 and 50 °C. One Phy unit (FTU) was defined as the